Plate Boundary Observatory Borehole Strainmeters: A New Way to Record "Slow Earthquakes" in Cascadia

Evelyn Roeloffs, U.S. Geological Survey, Vancouver, WA

NEPEC Workshop, 18 May 2007

USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

Plate Boundary Observatory (PBO)

- A component of the Earthscope initiative
- Funded by NSF
- Instrument types:
  - Continuous GPS
  - Borehole strainmeters
  - Laser strainmeters (not in Cascadia)

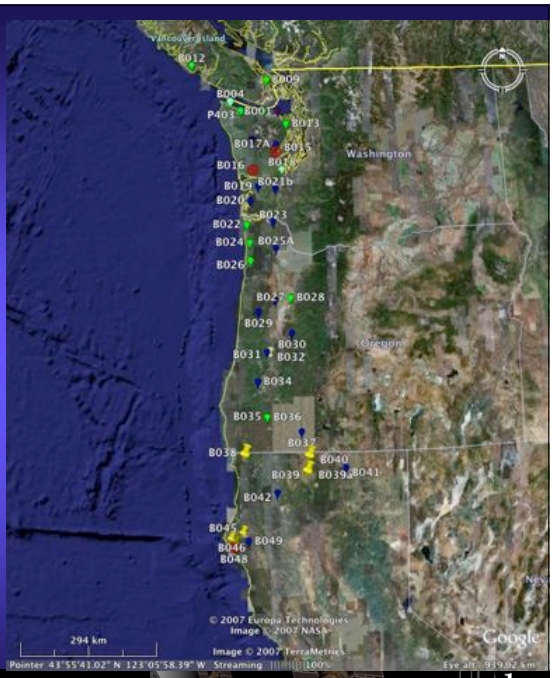
USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

Cascadia: A Major PBO Target

- 45 planned BSM's
- 16 now operating
- 5 drilled
- 2-4 additional stations may be added



USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

Gladwin Tensor Strainmeter

- Measures elongation along 4 horizontal azimuths
- Resolution 1 nanostrain (1 part per billion)
- Sampling rate 20 samples/s

USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

Features of PBO Strain Data

- Publically available through UNAVCO, IRIS, and NCEDC
- Most online data updated daily
- 1 sample-per-second data updated several times per day
- Real-time capability:
  - Not a mandate of PBO
  - Could be an option if separately funded

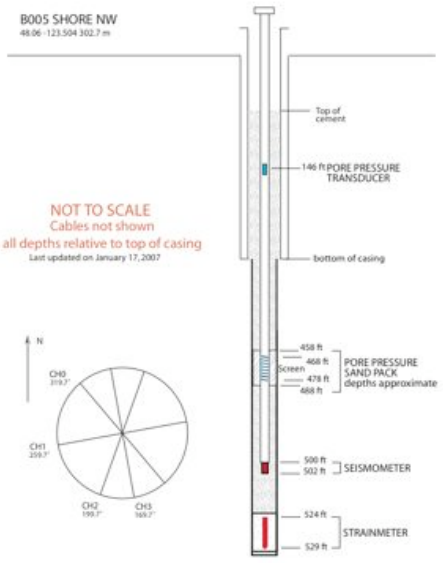
USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

PBO Borehole Installation

- Strainmeters must be permanently grouted into borehole
- Seismometers (3-comp, 1-Hz)are also cemented in
- Boreholes 500-800 ft deep



From UNAVCO PBO website

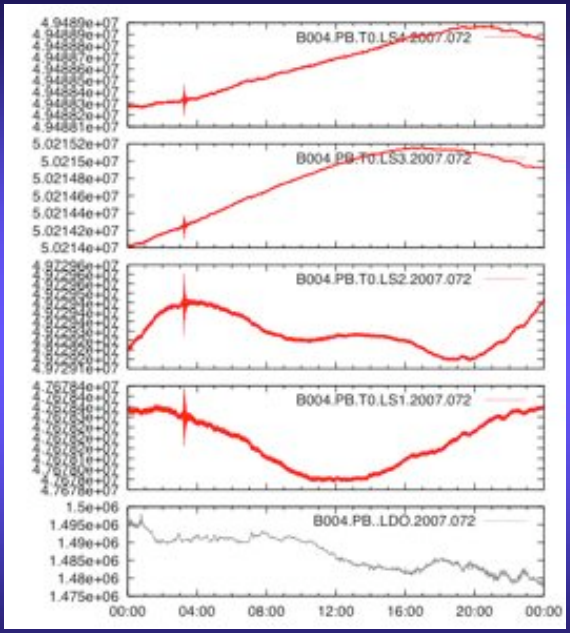
USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

B004
1 day

- 1 sample per second
- Available within about 5 hours from IRIS
- M6.0 earthquake in Gulf of California



USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

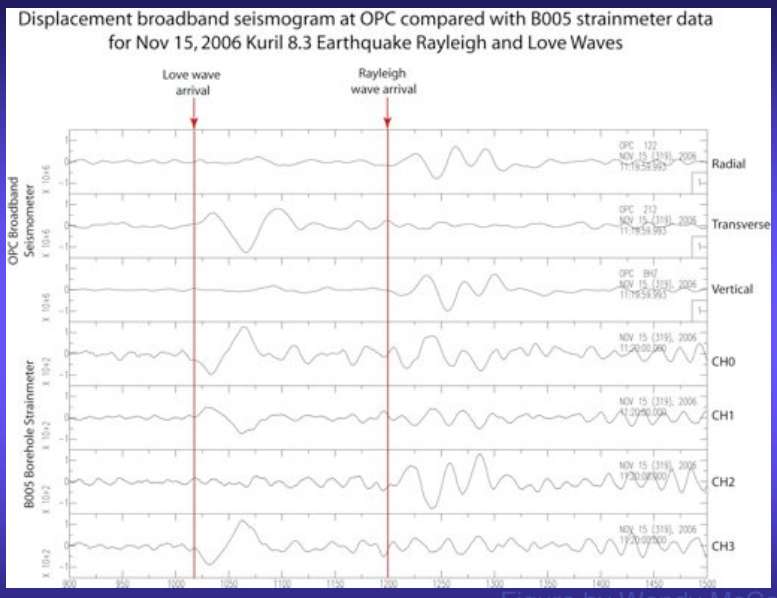


Figure by Wendy McCausland

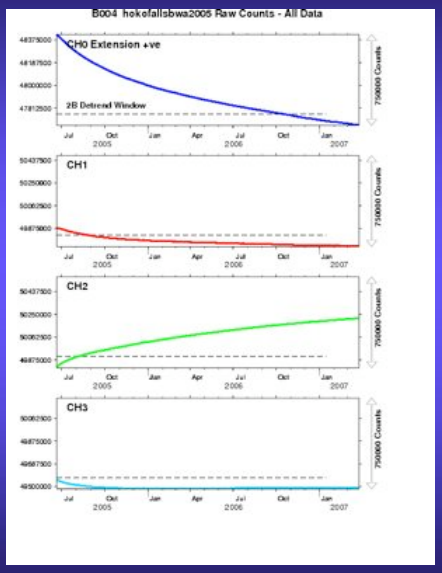
USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

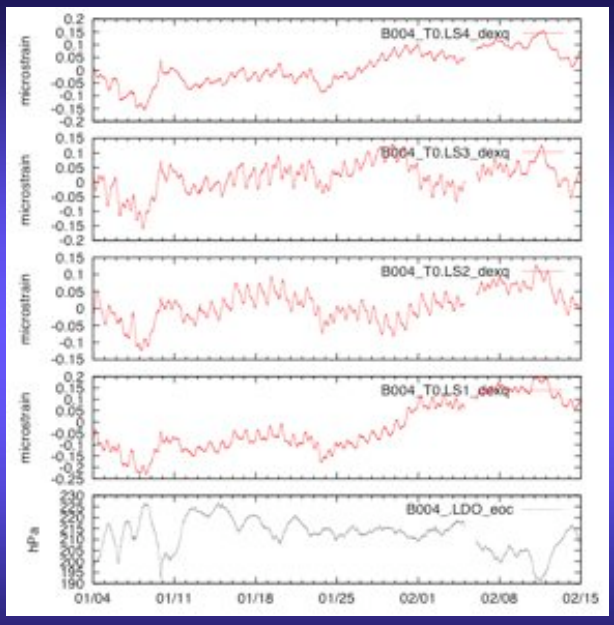
B004 - entire data record

- Long-term trends dominated by grout curing and borehole deformation
- Ideally long-term trend is contractional



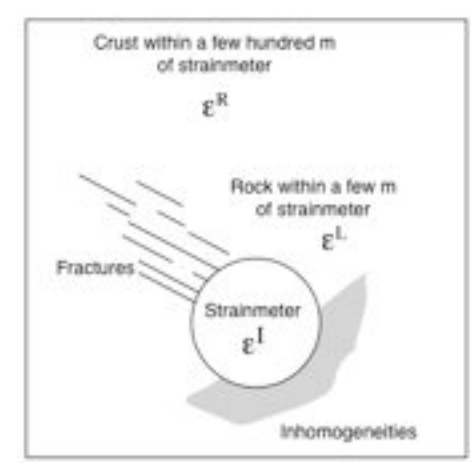
B004 Jan-Feb 2007

- Data have been edited, linearized and detrended



Goal: "Modelable" Strains

- Local strains differ from instrument strains in:
  - Overall amplitude
  - Ratio of shear strain to areal strain

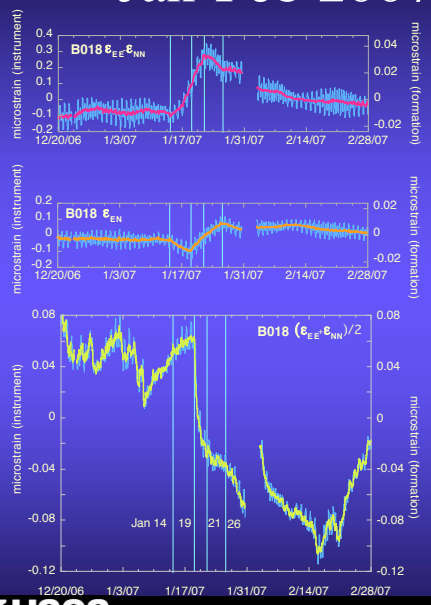


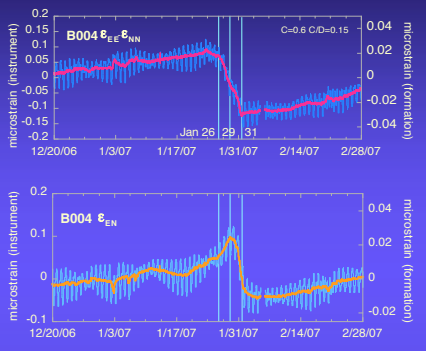
USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

Jan-Feb 2007 Cascadia ETS





(B004 Areal not shown - no detectable signal)

USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope

How Borehole Strainmeters Complement GPS

- Borehole strainmeters have much better time resolution than GPS
- Net strain is harder to infer from strainmeter data, due to increasing noise level with lengthening time period
- Absolute calibrations of strainmeters have some uncertainty

USGS science for a changing world

Plate Boundary Observatory
Supporting EarthScope Geodetic, Seismic, and Tectonic Research

earthscope